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(54) Improvements in or relating to monitoring devices

(57) A monitoring device is described suitable for use by fire-fighters. The unit combines the functions of a personal distress alarm and a gas pressure detector. The device has a pressure sensor and a movement sensor. An alarm means emits a signal of a first type when the pressure is reduced to a, or one of several, predetermined values, and a signal of a second type when no movement of the user is detected for a predetermined period of time.

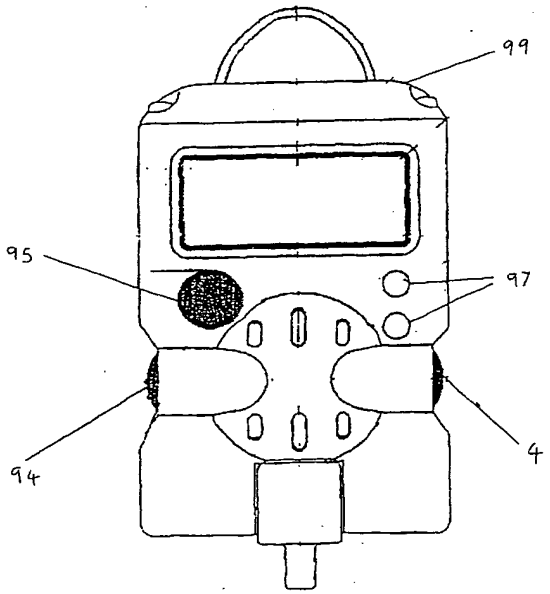

Fig 6

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EP 0 801 368 A1

Description

This invention relates to a monitoring device and is concerned with a monitoring device for use with breathing apparatus as worn by firefighters and the like.

Firefighters and other rescue personnel often work in hazardous environments where they may become incapacitated or immobilised. For this reason, they usually carry personal distress alarms which may be manually operated or which may activate automatically after the wearer has not moved for a predetermined time. Also, it is often necessary for such personnel to wear breathing apparatus comprising a container of breathing gas under pressure. In such circumstances, the apparatus includes a pneumatic and/or mechanical device which detects the pressure of gas in the container and emits a warning when the pressure has fallen below a certain level.

It is an object of the present invention to provide an improved monitoring device.

Accordingly, the present invention provides a monitoring device for operably connecting to breathing apparatus comprising a container of breathing gas under pressure, both the monitoring device and the breathing apparatus being worn by a user, which device comprises:-

a pressure sensor for detecting the pressure of gas in the container,
a movement sensor for sensing movement of the user, and
alarm means connected to the pressure sensor and the movement sensor for producing a signal of a first type when the pressure in the container is below a predetermined value and a signal of a second type when no movement of the user is detected after a predetermined period of time.

Preferably the signals of a first and second type are audible signals of different frequency to enable them to be distinguished from one another. One or both of the signals may rise or fall in pitch.

Advantageously, the alarm means connected to the pressure sensor and the movement sensor is adapted to produce a series of signals of the first type as the pressure in the container drops in use, each signal in the series being produced after there has been a predetermined drop in pressure since the previous signal in the series.

Preferably when the pressure in the container falls to a predetermined level, the pressure sensor causes the alarm to produce a signal to indicate to the wearer that he should evacuate to a safe area.

It is also preferred for the device to include a means of indicating the predicted time remaining before the container is devoid of gas. The signals are advantageously audible signals.

In a particularly preferred embodiment, the pressure sensor is operably connected to a display which provides a visible indication in analog and/or digital form of the gas pressure in the container.

Optionally, the device may include a means of manually activating the alarm means so as to cause it to produce the second signal irrespective of whether or not no movement has been detected for said period of time. In addition, the monitoring device may include an ambient temperature sensor in which case the temperature may also be indicated on a suitable display. Further, the pressure sensor may optionally include a means of detecting whether or not there is any leak of high pressure gas from the container by, for example, comparing the pressures at intervals of time.

In the event that the device includes a display, it may also include a means of actuating the alarm means to produce a signal to prompt the firefighter or the like to read the display in the event that the pressure detected by the pressure sensor falls below a predetermined value (which constitutes a first warning level) and/or, as appropriate, if the temperature detected by the temperature sensor exceeds a predetermined value.

In accordance with a preferred embodiment the monitoring device includes a receiver whereby it may be pre-programmed so as to enable said predetermined values/or said predetermined period of time to be selected as desired. Also, the monitoring device may include a transmitter whereby values detected by the device may be transmitted to an external location. The data transmission may be effected by means of an infra-red connection.

In an embodiment, the monitoring device is in two parts, namely a first unit incorporating the pressure sensor and operably linked to a main second unit comprising the alarm means, the movement sensor, interface functions as appropriate, and associated circuitry.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing in which:

Figure 1 is a perspective view of the main unit of a monitoring device in accordance with a first embodiment of the present invention,
Figure 2 is a perspective view of a second embodiment of a main unit,
Figure 3 is a flow chart exemplifying the embodiment of Figure 2,
Figure 4 is a schematic view of a third embodiment according to the invention,
Figure 5 shows a section through a fourth embodiment of the invention, and
Figure 6 shows a front view of the embodiment of Figure 5.

In the drawings, corresponding parts are denoted by like reference numerals.

Referring to Figure 1, the main unit comprises a

housing 1 including an automatic distress unit (ADSU) comprising an alarm means in the form of a piezo sounder and a movement sensor (not shown). The housing also includes an LCD display 2 positioned behind a protective window. The housing 1 is linked to another unit of the device comprising a pressure sensor (not shown) by means of a hose 3. The pressure sensor output is digital and holds its own calibration data in an electrical erasable programmable read only memory. The pressure sensor operates over a pressure range of from 0 to 300 bars and is connected to a container (not shown) for gas to be breathed by the user. A suitable manifold or pressure reducer (not shown) is provided to connect the pressure sensor to the container and preferably this is of modular construction so that it can be connected to gas containers of diverse designs. The hose 3 is capable of withstanding a high pull force (e.g. of about 500 Newtons) and carries electric cables to supply electric power to the electronic circuitry of the pressure sensor and also to enable the transmission of data between the pressure sensor and the main unit.

Located within the housing 1 is electronic circuitry operably linking the pressure sensor to the alarm means such that once the pressure in the container has fallen to a predetermined value (50 bar for example) the alarm means emits an audible whistle at a frequency of 3kHz for 30 seconds. Thereafter, the whistle is repeated at intervals until such time as the pressure falls to 10 bar. Also the circuitry is operably connected to the display 2 so that the pressure in the container is displayed graphically in an analog form and also digitally giving the actual pressure in the container in bars or pounds per sq. inch as desired. Further, the circuitry includes calculating circuitry to compute the time remaining before the pressure will drop to said predetermined value i.e. the time to the whistle being actuated (TTW) and this time too is displayed on the display upon actuation of a programmable first button 4 by the user. This calculating circuitry computes the average air consumption (by taking 3 readings over fixed short periods), links this to the remaining gas content in the container and presents the information in the form of a time related visual display indicating the time left before the whistle sounds. This provides the user with a realistic and everchanging indication of the time remaining before he should remove himself from the hazardous environment.

The circuitry within the main unit additionally includes an ambient temperature sensor and the detected temperature is also displayed on the display 2, as an alternative to the calculated time to the whistle, by pressing button 4. This circuitry may include a two stage preset (software adjustable) warning of increasing heat intensity and may also monitor the time for which the user has been subjected to a wide range of heat levels and trigger accumulated heat warnings.

The circuitry within the main unit also links the movement sensor to the alarm means such that, in the absence of movement for, for example, 25 seconds, the alarm emits a pre-warning signal at a frequency of 2kHz for, for example, 5 seconds. During this period, the firefighter can re-set the movement sensor by making some movement so that the distress signal is not actuated. In the absence of such re-setting during the 5 seconds for which the pre-warning signal is being emitted, the unit emits a distress signal at a frequency of from 3kHz down to 2kHz at 4 pulses per second.

The circuitry includes a second button (not shown but in a position corresponding to button 4 on the opposite side of the housing) which, on actuation by the user, causes the distress signal to be emitted. In this way, if the wearer is in distress but still conscious, he can instantly activate the alarm means to attract attention without having to remain stationary for the predetermined length of time.

The circuitry within the main unit may also include a means of actuating the alarm means to produce signals intended to warn the user to read the display when, for example, the temperature exceeds a predetermined value or the pressure in the container for the breathing gas falls below each of a series of predetermined values.

In order to facilitate reading the display, the device may include a backlight activated by a third button (not shown).

The device includes an infra-red communication port 5 whereby the device may be pre-programmed so as to select suitable predetermined gas pressures and periods of time as appropriate and whereby information detected by the device may be transmitted externally.

The electronic circuitry within the main unit 1 may include a data logging means, a timer to monitor the hours of usage, and a battery state checking means.

Thus, for example, data logging may occur every 5 seconds and the data logging means may store, for example, the time elapsed since powering up when the battery is connected, the gas pressure in the container, the temperature, and the occurrence of any alarms and errors. This data can then be transmitted externally every 5 seconds via infra-red link. In the case where a digital radio is provided and is fitted with an infra-red link, the data can be sent to the Incident Manager monitoring the activity of the user.

The main unit 1 may also include circuitry to provide an indication on the display 2 in the event that the connection between the pressure sensor and the breathable gas container lacks integrity.

Referring now to Figures 2 and 3, there is shown an embodiment of the main unit wherein the buttons have different functions. In this case, free programmable button 10 activates the start of the leak test, free programmable button 11 (not shown but located on the opposite side of the housing in a position corresponding to button 10) enables the type of cylinder to be selected and also data to be entered or cancelled, button 12 is a panic button whereby the user can manually activate the alarm means when in distress, and button 13 (not shown

but located at the rear end of the ho[redacted] activates the display backlight. Actuation of buttons 10 and 11 together cancels the alarm and returns the system to idle mode (switch off).

The third embodiment of the invention will now be described with reference to Figure 4. The device includes a main module 55 comprising a housing 71 including an automatic distress unit (ADSU) comprising an alarm means 63 and a movement sensor 57. The housing is shock proof and air tight and includes an LCD display 59 positioned behind a protective window. The housing 71 is linked to another unit of the device comprising a pressure transducer 52 by means of an electrical cable 53 protected by a sturdy outer sheath 54. The pressure transducer 52 is connected by means of connector 51 to a high pressure container or adaptor (not shown) for gas to be breathed by the user. A seal 60 is provided to prevent escape of gas.

Located within the housing 71 is electronic circuitry operably linking the pressure transducer cable 53 to the alarm means 63. The circuitry includes circuit board 58 powered by battery 56 and is such that an audible signal is produced each time the pressure in the container falls, during use, by a specific, predetermined amount e.g. by 10 bars. Also a signal is produced when the pressure drops to a predetermined value to warn the wearer that he should move to an area where breathing assistance is not needed. Also the circuitry is operably connected to the display 59 so that the pressure in the container is displayed. Further, the circuitry includes calculating circuitry to compute the time remaining before the pressure will drop to said predetermined value and this time too is displayed on the display upon actuation of a first button 61 by the user. This provides the user with a realistic and everchanging indication of the time remaining before he should remove himself from the hazardous environment.

The circuitry within the module 55 also links the movement sensor 57 to the alarm means 63 such that, in the absence of movement for, for example a predetermined time, for example 25 seconds, the alarm means emits a pre-warning signal. At this time, the user can re-set the movement sensor so that the distress signal is not actuated. In the absence of such re-setting after a specified time, the unit emits the distress signal to draw attention to the possibility that the wearer is unconscious or otherwise incapacitated. The circuitry includes a second button 64 which, when actuated simultaneously with button 61 for a given length of time, causes the distress signal to cease in the event of inadvertent actuation. Buttons 61 and 64 are preloaded to prevent accidental mis-use. If the wearer is in distress but still conscious, he can instantly activate the alarm means to attract attention by simultaneously pressing buttons 61 and 64 without having to remain stationary for the predetermined length of time.

The device includes an infra-red communication port 55 whereby the device may be pre-programmed so as to select suitable predete[redacted]d gas pressures and periods of time as appropriate and to enable the device to be used with gas containers of different designs and sizes.

The device is ordinarily in a mode where the power is continuously on but where it is dormant until pressure is applied by the breathing gas on transducer 52 which causes the device to adopt its activated mode. This is indicated on the display 59. A self check mode then commences to check the alarm means 63 and motion sensor 57. Thereafter the device switches to ready mode awaiting a change in gas pressure or other event. The device is switched off by depressing button 62 for a predetermined time.

To ensure that all data is recorded prior to the user entering an hazardous situation, an electronic key 66 stores data from a chip in the module 55. This key 66 is removed by, say, the control officer, and placed in a record box which downloads, for instance, name of wearer, breathing gas container pressure, breathing gas container volume, predicted time of use based on standard breathing rate, predicted time to audible warning activation, time of entry etc.

Another embodiment of the invention will now be described with reference to Figures 5 and 6. Like components have been given the same reference numerals as in the first embodiment.

A housing 1 is made of rigid gas-inpermeable plastic. A piece of soft, flexible plastic 81 is clipped onto the outside of the lower half of the case.

A piezoelectric sounder 83 is glued into the housing 1 by an epoxy ring 85. The epoxy ring provides a gas-tight seal of the sounder to the housing.

A printed circuit board 87 is mounted within the housing. A motion sensor 89 is mounted at one end of the printed circuit board 87. Various other components forming the control circuitry 91 are also provided on the printed circuit board 87.

The printed circuit board is also connected to a battery compartment 93, adapted to hold a PP3 battery.

LEDs 97 are mounted on the printed circuit board for displaying the status of the unit. Further LEDs 98 are mounted within a transparent housing 99 to give a visual indication of an alarm condition.

A panic button 95 is mounted on the front face of the unit. Two buttons 4, 94 are provided on the side of the casing to activate and deactivate the unit.

A temperature sensor is also provided, electrically attached to the printed circuit board.

A connecting hose (not shown) electrically connects the printed circuit board 87 to a pressure sensor, which in use is connected to a twin port manifold mounted on the medium pressure outlet of a reducer attached to a gas cylinder in the usual way.

A holder (not shown) is provided to hold the unit when not in use.

In use, the unit has three modes; an off mode, an active mode and an alarm mode. The unit automatically

enters active mode when the pressure sensor detects a high ambient pressure, i.e. when the valve on a high pressure gas cylinder connected to the unit is opened. Alternatively, the unit can be switched on by simultaneously activating the buttons 4, 94.

The alarm sounds either when the panic button 95 is depressed when the unit is in active mode, or when the motion sensor detects that the unit has not moved for a predetermined period of time, typically 30 seconds. To prevent accidental activation of the alarm, a further warning tone sounds 5 seconds before the alarm activates, to allow the user to move and thus prevent the alarm from sounding.

The unit can be switched off by simultaneously pressing the buttons 4, 94 but only when the pressure sensor detects atmospheric pressure, or at least less than 60 psi (4 bar, 4×10^5 Pa). Further, the unit must be in the retaining holder to allow it to be switched off. Thus the unit also acts as a so-called 'Tally PASS' system, in which the unit can only be switched off once a user, particularly a fire-fighter, has left an incident. This helps ensure that no fire-fighter is forgotten; if the unit is not returned to the retaining holder then a search for the missing fire-fighter can be carried out.

Claims

1. A monitoring device for operably connecting to a breathing apparatus comprising a container of breathing gas under pressure, both the monitoring device and the breathing apparatus being worn by a user, which device comprises:

   a pressure sensor (51) for detecting the pressure of gas in the container,
   a movement sensor (57) for sensing the movement of the user, and
   alarm means (63) connected to both the pressure sensor (51) and the movement sensor (57) adapted to produce a signal of a first type when the pressure in the container is below a predetermined value and signal of a second type when no movement of the user is detected after a predetermined period of time.

2. A monitoring device according to claim 1 in which the said alarm means (63) is adapted to produce a series of signals of the first type as the pressure in the container drops in use, each signal being produced after there has been a predetermined drop in pressure since the previous signal in the series.

3. A monitoring device according to claim 2, in which when the pressure in the container falls to a predetermined level, the pressure sensor (51) causes the alarm to produce a signal to indicate to the user that he should evacuate to a safe area.

4. A monitoring device according to any preceding claim, in which the signals of the first and second types are audible signals at different frequencies.

5. A monitoring device according to any preceding claim in which the pressure sensor (51) is operably connected to a display (59) which gives a visible indication of the gas pressure in the container.

6. A monitoring device according to claim 5, further comprising a means of activating the alarm means (63) to prompt the user to read the display (59) in the event that the pressure detected by the pressure sensor falls below a predetermined warning level.

7. A monitoring device according to any preceding claim, further comprising a means (61,64) for manually activating the alarm to produce a signal of the second type.

8. A monitoring device according to any preceding claim further comprising a means for detecting leakage of high pressure gas from the container.

9. A monitoring device according to claim 8, in which the means for detecting leakage compares the pressure measured by the pressure sensor at intervals of time.

10. A monitoring device according to any preceding claim further including a temperature sensor, and a display (59) for displaying the temperature.

11. A monitoring device according to claim 10 having a means to actuate the alarm means, to prompt the user to connect the display, when the temperature measured by the temperature sensor exceeds a predetermined value.

12. A monitoring device according to claim 1 including a receiver (55) for receiving new values for said predetermined value of pressure and said predetermined time, and a storage means for storing the new values.

13. A monitoring device according to claim 12 further including a transmitter whereby a value measured by a sensor may be transmitted to an external location.

14. A monitoring device according to claim 13 in which the receiver (55) is an infra-red receiver and the transmitter is an infra-red transmitter.

15. A monitoring device according to any preceding claim including

a first unit (71) incorporating the pressure sensor, and

a second unit (51,52) incorporating the alarm means (63), the movement sensor (57), any necessary interface functions and associated circuitry,

the two units being operably connected together.

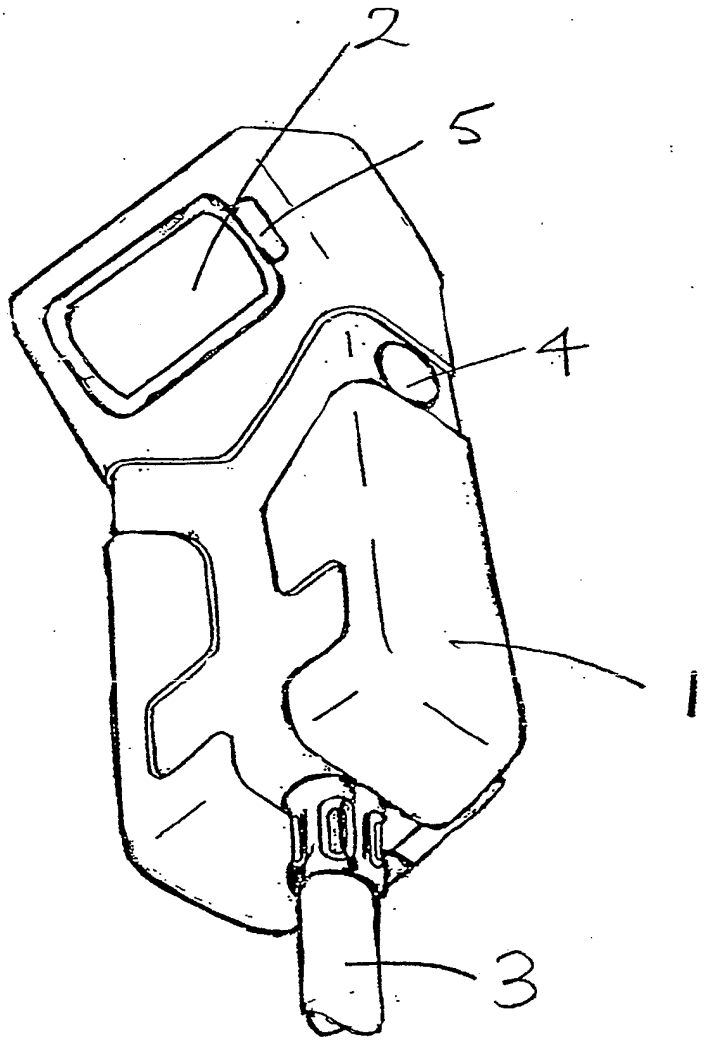

FIG. 1

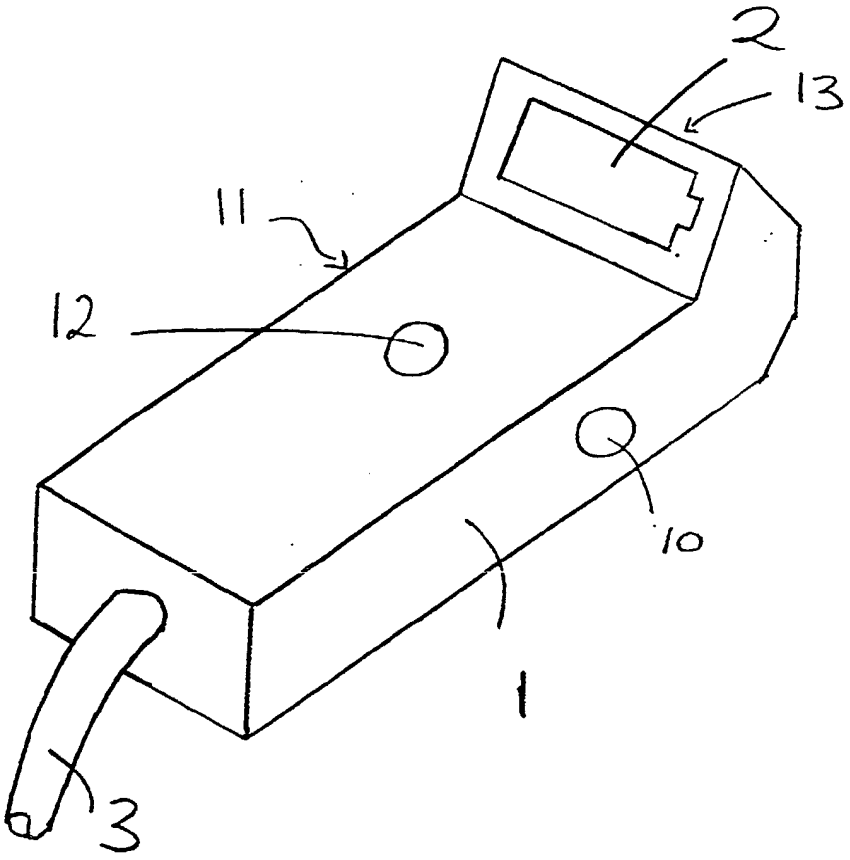

FIG. 2

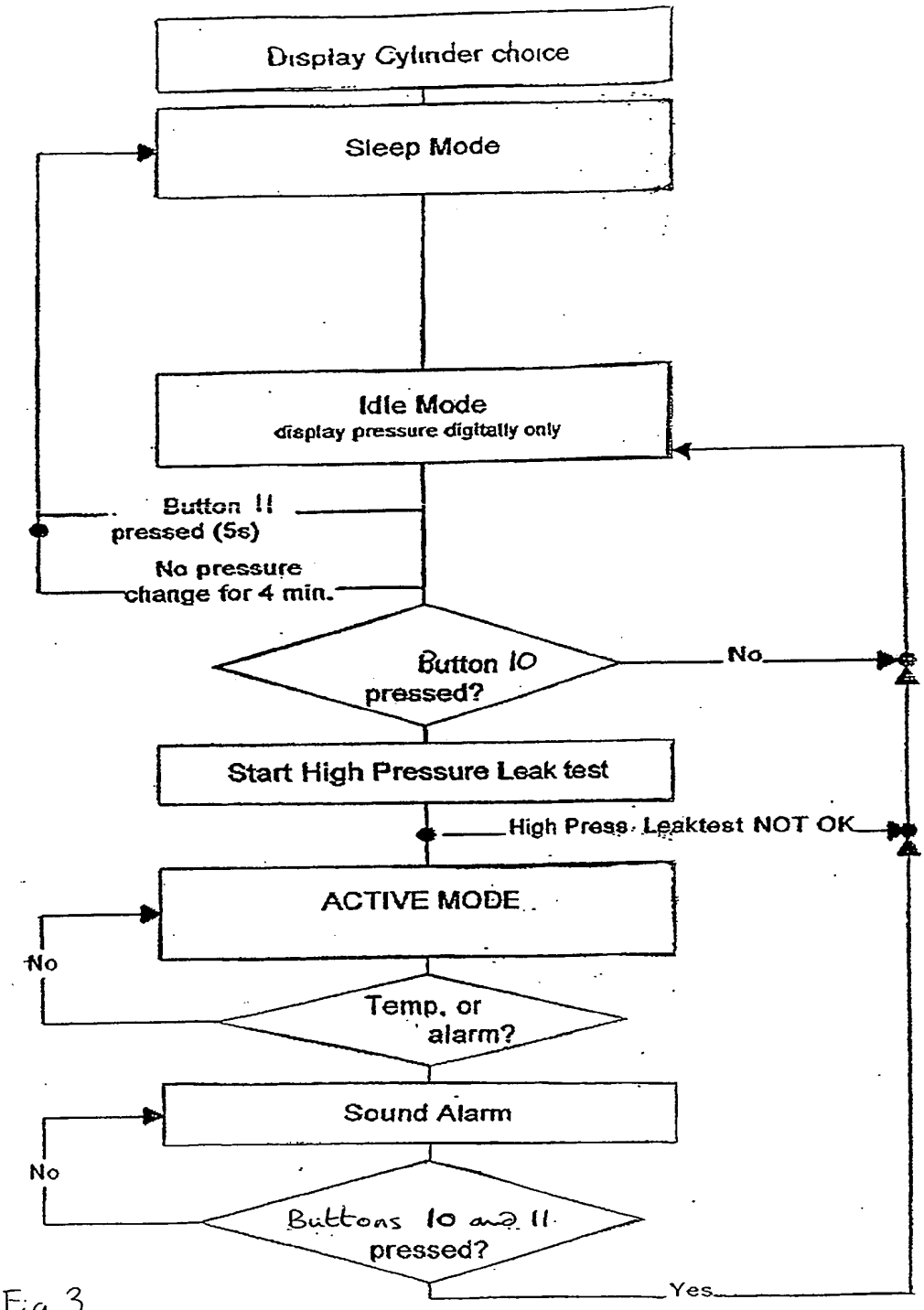

Fig 3

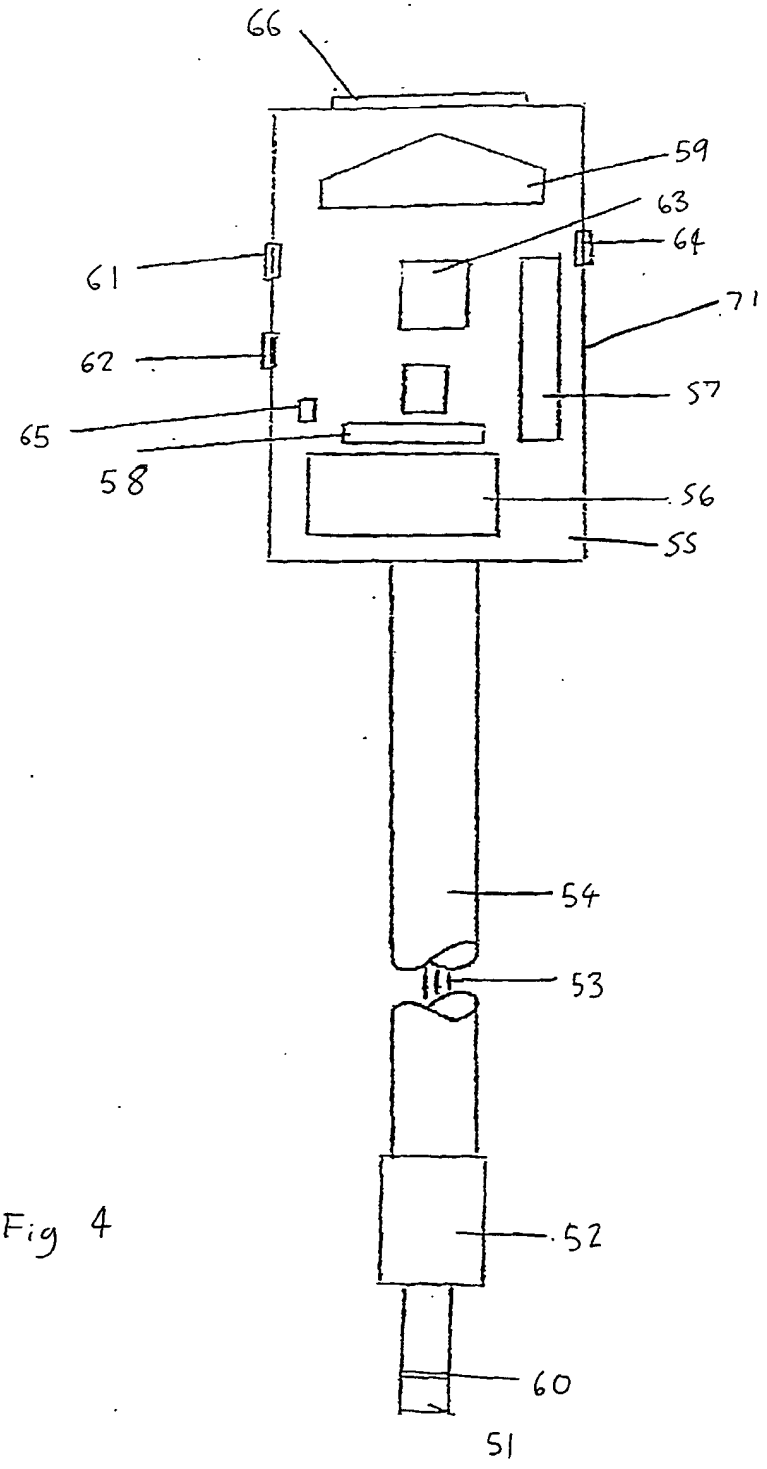

Fig 4

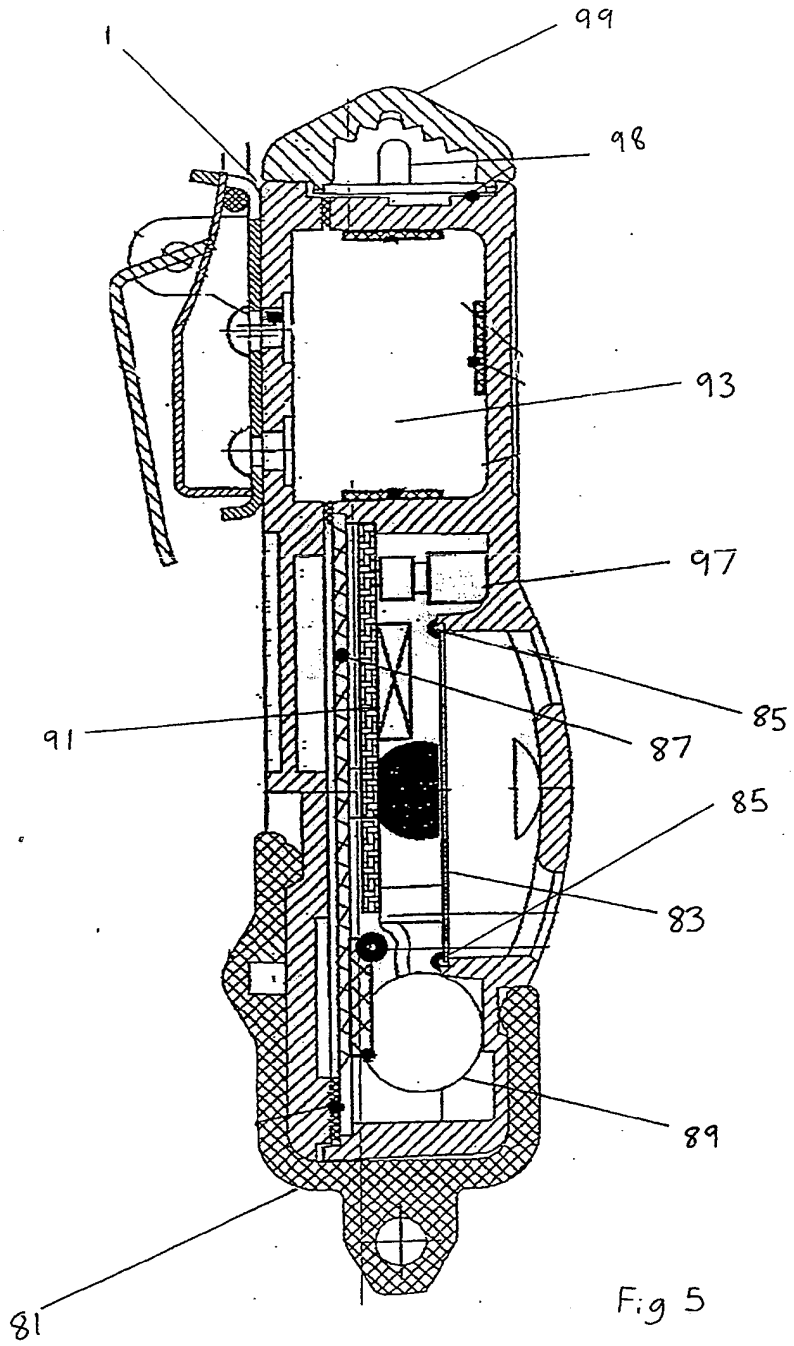

Fig 5

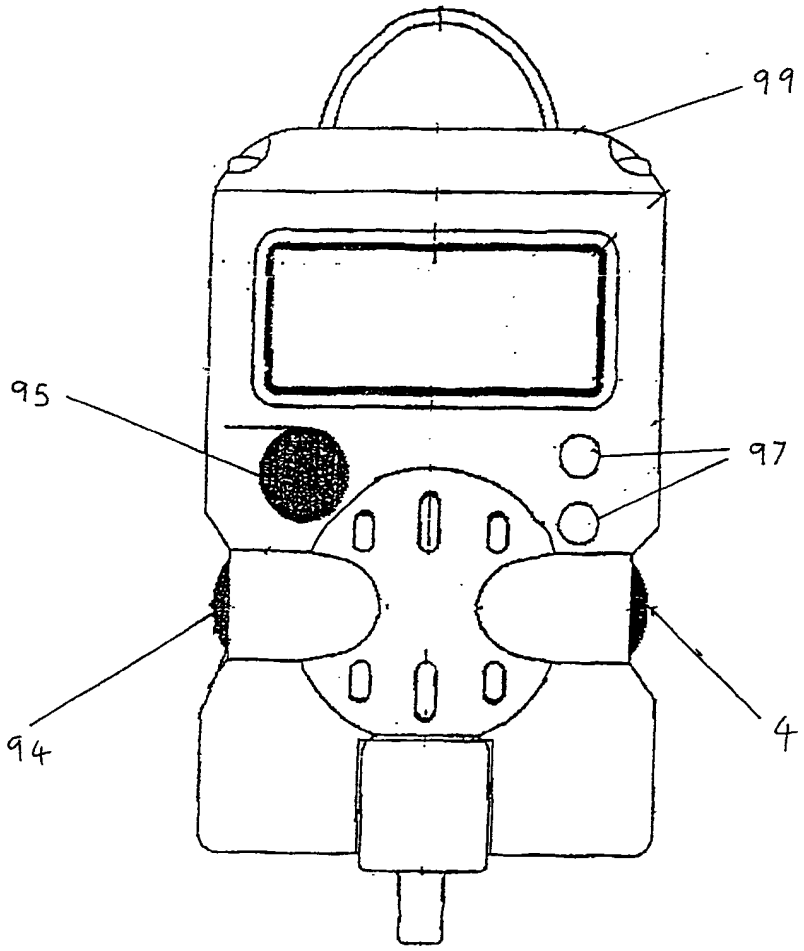

Fig 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 2471

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 5 157 378 A (STUMBERG L HERBERT ET AL) 20 October 1992 * column 2, line 4 - line 65; figure 1 * * column 4, line 53 - column 5, line 12; figures 3-5 *	1-3	G08B21/00
E	WO 97 19726 A (MINE SAFETY APPLIANCES CO) 5 June 1997 * claim 1 *	1	
A	US 5 317 305 A (CAMPMAN JAMES P) 31 May 1994 * abstract; figures 1-5 * * column 3, line 36 - line 42 *	1,4	
A	EP 0 428 131 A (CAIRNS & BROTHER INC) 22 May 1991 * abstract; figure 1 *	5	
A	WO 80 00516 A (CATALDO T) 20 March 1980 * abstract; figure 1 *	7,13	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US 5 492 110 A (LENZ VERNON C ET AL) 20 February 1996 * column 2, line 22 - line 39; figures 1,2 *	13	G08B A62B
A,P	US 5 541 579 A (KIERNAN CHRISTOPHER) 30 July 1996 * abstract; figure 1 *		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	22 July 1997	Breusing, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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